AD-A047 516 ARMY TANK-AUTOMOTIVE MATERIEL READINESS COMMAND WARR--ETC F/G 13/6
CANNIBALIZATION OF 5-TON TRUCKS.(U)
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CANNIBALIZATION OF 5-TON TRUCKS

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AUGUST 1977

R. G. JOULES

TARCOM

SYSTEMS ANALYSIS DIVISION, PLANS & ANALYSIS DIRECTORATE

U.S. ARMY TANK AUTOMOTIVE MATERIEL READINESS COMMAND

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER SA-77-10	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 Cannibalization of 5-Ton Trucks.		5. TYPE OF REPORT & PERIOD COVERED 9 Final rept.,
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R.G. Joules 10 Reginald G. Joules		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Systems Analysis Plans & Analysis Directorate (DRSTA-SA) 12 43p.		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Materiel Management Directorate, TARCOM, Warren, MI 48090		12. REPORT DATE 11 Aug 77
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 14 TARCOM-SA-77-10		15. SECURITY CLASS. (of this report) UNCLAS
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Cannibalization, 5-Ton Trucks

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Determine the shortage of 5-Ton Truck gas (R6602) and multifuel (LDS 465/1A) engines from June 1977 through September 1981. Estimate the cost of cannibalizing excess 5-Ton Trucks to obtain engines to fill these deficits.

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CANNIBALIZATION OF 5 TON TRUCKS

By

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Systems Analysis Div
Plans & Analysis Directorate

FOREWORD

The author wishes to acknowledge the prompt assistance of Mr. Clarence Wheeler of Cost Analysis Division, Comptroller in costing the cannibalization schedules.

I. PURPOSE:

The purpose of this study is to determine the total deficits of 5 Ton Truck gas (R6602) and multifuel (LDS 465/1A) engines expected between June 1977 and September 1981, and estimating the cost of cannibalizing excess vehicles around the world to obtain engines to fill these deficits.

II. SCOPE:

The analysis considers only cannibalization of excess 5 Ton Trucks as a source of supply of engines. Other alternatives such as buying replacement engines, possible modification of some other engines for replacements, or early replacement of the fleet are not addressed.

III. BACKGROUND:

A. The shortage is created by the fact that new replacement engines available do not meet EPA clean air standards.

B. Other alternatives are being studied by other organizations.

C. In this study only one source of supply to meet the deficits is considered, namely, cannibalization.

D. The study establishes the total demand during the period from June 1977 through September 1981, based upon the following factors:

1. Given projections of monthly demands.

2. An overall prpeline demand that is equal to four times the average monthly demand.

3. Existing backorders.

E. The operational readiness is not considered as a factor in this study; it is assumed that all demands must be met, that no slack is allowed.

F. The basic data such as monthly demands, current stock of serviceable and unserviceable engines, vehicle washout rates, engine loss and washout rates, distribution of vehicles according to location, etc. were provided by the Tactical Vehicle Division.

G. The cannibalization schedules were costed by Cost Analysis Division, Comptroller Directorate.

IV. APPROACH:

A. Since the problems of gas and multifuel engines are similar but separate, compute the values separately, but use identical steps.

B. On a year-by-year basis, compute the deficits. Take into account existing backorders, pipeline requirements, monthly demands from the field, monthly returns from the field, loss of returnable engines in the field, loss due to washout, and available supply of serviceable and unserviceable engines. (Overview Flow Diagram (OFD), Function Block 1.0).

C. On a year-by-year basis, compute the number of excess vehicles that will be available for cannibalization by using the projected vehicle washout rates. Using the engine loss rates (loss in the field + loss at depot level), estimate the number of rebuildable engines that will be available from the excess vehicles. (OFD, Function Block 2.0).

D. Compare the yearly deficits to the number of rebuildables that will be available from the yearly excess lots. If the deficit during a given year is larger than the supply of rebuildables, the difference will have to be made up by the extras available from previous years. (OFD, Function Block 3.0).

E. Once the total cannibalization requirement for each year is determined, develop a breakdown of cannibalization based upon geographical location. Since the overall expenses for labor and transportation to depot (which is located in the U. S.) will be the cheapest in the U.S. and the most expensive in the Pacific, cannibalization should be maximized in the U. S. and minimized in the Pacific, with Europe handling the overflow from the U. S. Therefore, if there are not enough cannibalizable trucks in the U. S. during a given year, the supply in the U. S. during the previous years should be searched first before scheduling cannibalization in Europe, and in the Pacific. (OFD, Function Blodk 4.0).

F. Translate the requirements for rebuildable engines to the number trucks to be cannibalized. This is to allow for the losses described above while discussing availability. (OFD, Function Block 5.0).

G. Obtain cannibalization and shipping costs and calculate the total cost of this program.

STUDY APPROACH
OVERVIEW FLOW DIAGRAM

COMPUTE
YEARLY DEFICITS 1.0

↓

COMPUTE NUMBER OF
REBUILDABLE ENGINES
THAT MAY BE OBTAINED
THROUGH CANNIBALIZATION 2.0

↓

COMPUTE YEARLY REQUIRE-
MENTS FOR REBUILDABLES
(MAY OR MAY NOT CORRESPOND
TO YEARLY DEFICITS) 3.0

↓

COMPUTE AVAILABILITY OF
REBUILDABLES WITH
RESPECT TO TIME AND LOCATION 4.0

↓

CONVERT REQUIREMENTS FOR
REBUILDABLES TO CANNIBALIZATION
REQUIREMENTS TO OBTAIN
CANNIBALIZATION SCHEDULE 5.0

↓

CONSULT COST ANALYSIS
FOR COST 6.0

STUDY APPROACH
FUNCTION DIAGRAM 1.0

COMPUTE DEMANDS

- - - - - - - - - - - -

CONSIDER

BACK ORDERS
PIPELINE REQUIREMENTS
MONTHLY DEMANDS 1.1

↓

COMPUTE SUPPLY

- - - - - - - - - - - -

CONSIDER

CURRENT STOCKS
RETURNS FROM FIELD 1.2

↓

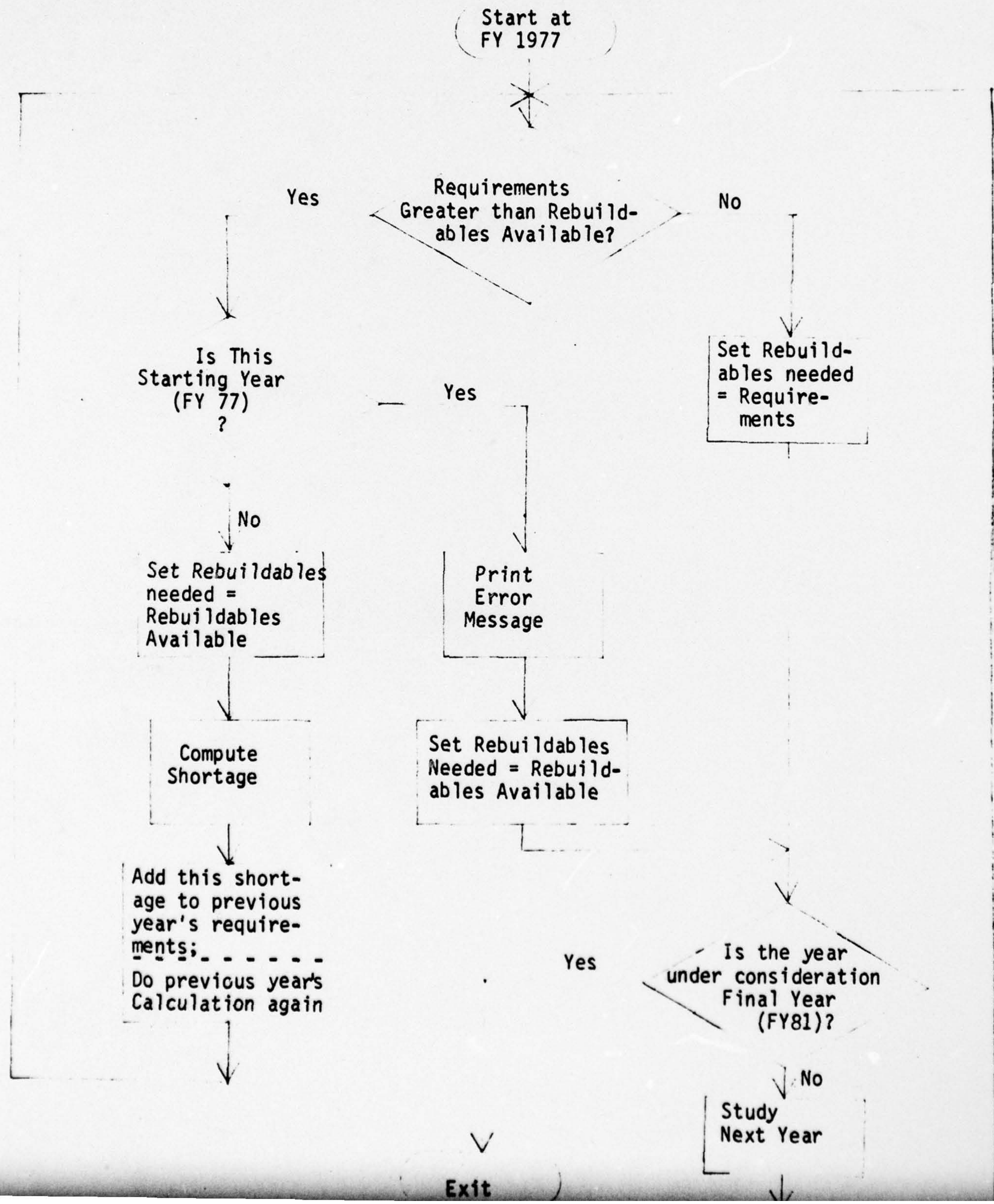
COMPUTE DEFICITS 1.3

STUDY APPROACH
FUNCTION DIAGRAM 2.0

COMPUTE YEARLY
EXCESS VEHICLES 2.1

COMPUTE REBUILDABLES
THAT WILL BE AVAILABLE
FROM THESE EXCESS VEHICLES 2.2

STUDY APPROACH
FUNCTION DIAGRAM 3.0



STUDY APPROACH
FUNCTION DIAGRAM 4.0

COMPUTE AVAILABLE REBUILDABLES WITH RESPECT TO YEAR FOR U.S., EUROPE AND PACIFIC
4.1

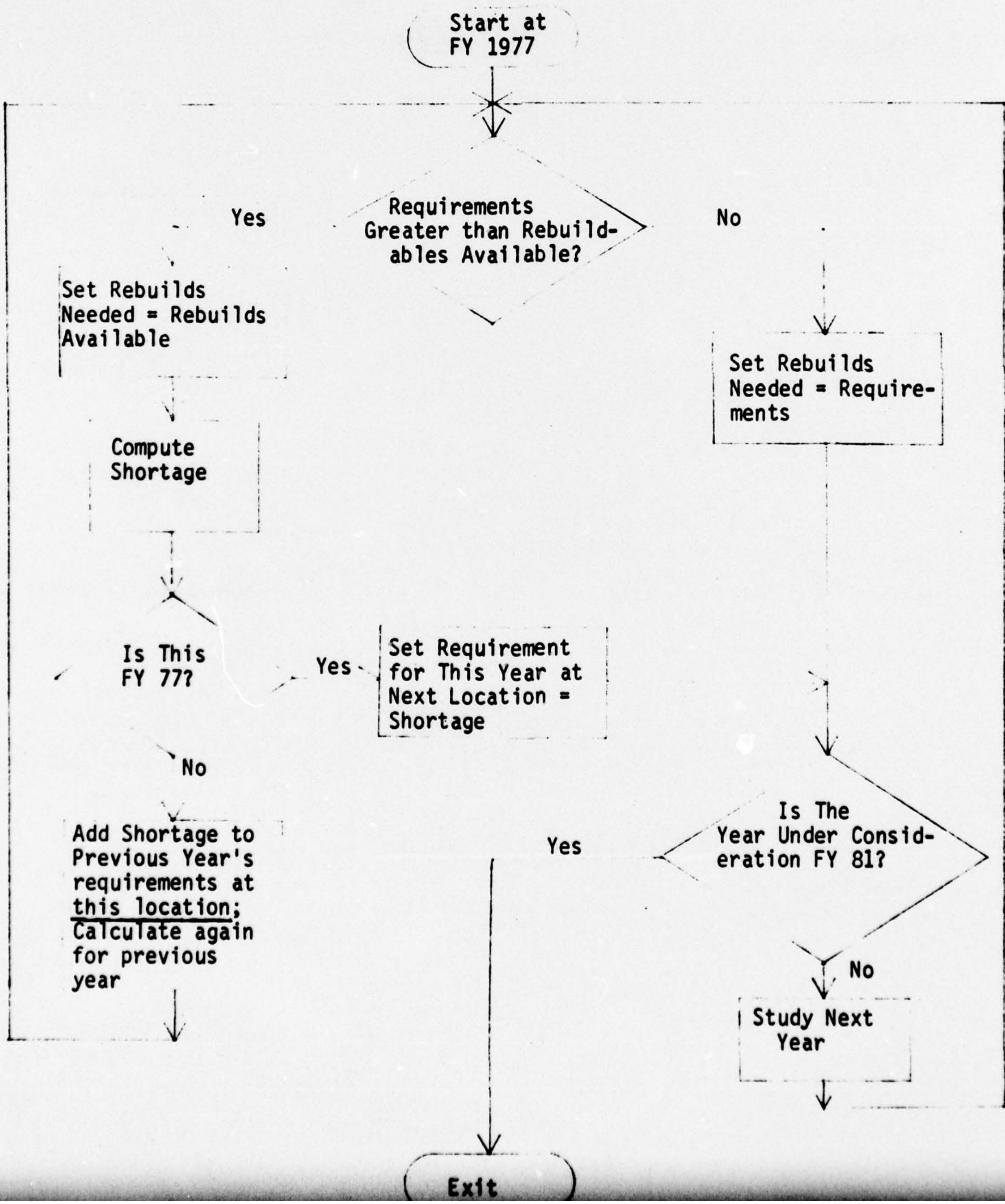
COMPUTE REBUILDABLES NEEDED FROM U.S. EVERY YEAR (USE 4.2.1)
4.2

COMPUTE REBUILDABLES NEEDED FROM EUROPE EVERY YEAR (USE 4.2.1)
4.3

COMPUTE REBUILDABLES NEEDED FROM PACIFIC EVERY YEAR (USE 4.2.1)
4.4

STUDY APPROACH

FUNCTION DIAGRAM 4.2.1



V. ASSUMPTIONS

A. Starting deficit (deficit at end of FY76) is assumed to be zero for both categories.

B. Pipeline demand, numerically equal to four times the monthly demand, is to be met in FY77. Therefore, there will be no pipeline demands in the following years, as long as there is constant flow.

C. Since no gas vehicle washout rate is available for FY81, the rate is assumed to be zero.

D. The vehicle washout rate and engine loss rate will be uniform in U.S., Europe and the Pacific areas.

E. Engine loss rate is constant during the period under consideration (June 1977 - September 1981).

F. Distribution of vehicles over the three areas remains constant during the period under consideration (gas trucks: 85% in U.S., 13% in Europe, 2% in the Pacific; multifuel trucks: 67% in U.S., 24% in Europe, 9% in the Pacific).

VI. DISCUSSION

Deficits:

Tables 1 and 2 show the yearly supply, yearly and cumulative demand and cumulative deficits by considering the factors discussed in Approach. These tables clearly illustrate the problem.

A negative deficit during a given year in effect decreases the total demand for the following year.

DEMAND is the sum of total demand from the field over the year, pipeline demands (if any), back orders (if any), and previous deficits.

SUPPLY is the sum of net returns of unserviceables (through rotation, after losses), serviceable stock (if any), and unserviceable stock (if any).

DEFICIT = DEMAND - SUPPLY

TABLE 1. CUMULATIVE DEFICITS OF GASOLINE ENGINES

FY	YEARLY DEMAND	CUMULATIVE DEMAND	YEARLY SUPPLY	CUMULATIVE DEFICIT
77 (May - Sep)	762	762	845	-83
78	468	385	316	69
79	468	537	316	221
80	468	689	316	373
81	468	841	316	525*

*Total deficit is 525

Basic Input Data used for developing this Table:

Net monthly unserviceables through rotation after losses (10% field loss and 25% washout) is

$$39 * (1 - 0.1) * (1 - 0.25) \simeq 26$$

Serviceable stock on hand as of May 31, 77 is 222.

Unserviceables on hand after washout is $691 * (1 - 0.25) \simeq 518$

Backorders as of May 31 = 450

Pipeline demands = 4 * 39 = 156

TABLE 2. CUMULATIVE DEFICITS OF MULTIFUEL ENGINES

FY	YEARLY DEMAND	CUMULATIVE DEMAND	YEARLY SUPPLY	CUMULATIVE DEFICIT
77 (May - Sep)	1266	1266	1304	-38
78	1404	1366	884	482
79	1404	1885	884	1001
80	1404	2405	884	1521
81	1403	2924	884	2040*

*Total deficit is 2040

Basic Input Data used for developing this Table:

Net monthly unserviceables through rotation after losses (10% field loss and 30% washout) is

$$117 * (1 - 0.1) * (1 - 0.30) \simeq 74$$

Serviceable stock on hand as of May 31, 77 is 153.
Unserviceables on hand after washout is 1233 * (1 - 0.3) $\simeq$ 856
Back orders as of May 31 = 330
Pipeline demands = 4 * 117 = 468

B. <u>Availability of Rebuildables through Cannibalization:</u>

Tables 3 and 4 show the number of trucks that will be available for cannibalization based upon vehicle washout rates, and the rebuildable engines that can be obtained from these excess vehicles after allowing for normal losses.

$$\text{Total strength for a given year} = \text{Total Strength for previous year} * \left\{1 - \text{Vehicles washout rate for previous year}\right\}$$

$$\text{Trucks available for cannibalization during a given year} = \text{Total strength for the year} * \text{Vehicle washout for that year}$$

$$\text{Loss rate of unserviceable engines} = \left\{1 - \text{field loss rate}\right\} * \left\{1 - \text{washout rate at depot}\right\}$$

TABLE 3. AVAILABILITY OF REBUILDABLE GASOLINE ENGINES

FY	Total Strength	Vehicle Washout Rate	Trucks Available For Cannib.	Engine Loss Rate	Rebuildable Engines Available
77	6752	0.13	879	0.325	592
78	5874	0.02	117	0.325	79
79	5757	0.02	115	0.325	78
80	5642	0.15	846	0.325	571
81	4796	-	0	0.325	0

TABLE 4. AVAILABILITY OF REBUILDABLE MULTIFUEL ENGINES

FY	Total Strength	Vehicle Washout Rate	Trucks Available For Cannib.	Engine Loss Rate	Rebuildable Engines Available
77	9792	0.02	166	0.37	105
78	8157	0.02	163	0.37	103
79	7994	0.02	160	0.37	101
80	7834	0.02	157	0.37	99
81	7677	0.02	154	0.37	97

C. Deficits vs Availables:

The yearly deficits shown in Tables 1 and 2 are cumulative since they are intended to show the deficits if no action is taken to curb the shortage. Tables 5 and 6 compare the yearly shortages and the rebuildable engines that could be obtained through cannibalization. The last columns show the yearly deficits after cannibalization.

As mentioned earlier if the shortages during a given year is greater than the number of rebuildables available from cannibalization, excess rebuildables available from previous years should be used to cover the difference. The fourth columns in Tables 5 and 6 show the number of rebuildables that should be made available each year.

TABLE 5. DEFICITS VERSUS AVAILABLES OF GASOLINE ENGINES

FY	Shortages	Potential Rebuildables From Cannibalization	Number of Rebuildables Needed (From Availables)	Deficits After Cannibalization
77	0	592	64	0
78	69	78	78	0
79	152	79	79	0
80	152	571	304	0
81	152	-	-	0
Totals	525		525	0

Note that there will be a shortage of 152 engines in FY81, but no trucks will be available for cannibalization. Therefore, 304 rebuildables should be made available in FY80 (even though the shortage in FY80 will be only 152) to cover the shortage in FY81.

Similarly, though there will be no shortage in FY77, 64 rebuildables should be made available in FY77 to cover the shortage in FY79.

TABLE 6. DEFICITS VERSUS AVAILABLES OF MULTIFUEL ENGINES

FY	Shortages	Potential Rebuildables From Cannibalization	Number of Rebuildables Needed (From Availables)	Deficits After Cannibalization
77	0	105	105	0
78	482	103	103	274
79	519	101	101	418
80	520	99	99	421
81	519	97	97	422
Totals	2040		505	1535*

*Note that even if all available excess multifuel trucks are cannibalized, the shortage cannot be met

D. Source Breakdown in Terms of Year and Location:

Tables 7 and 8 show from where required rebuildables will be obtained.

TABLE 7. SOURCE BREAKDOWN IN TERMS OF YEAR AND LOCATION FOR GASOLINE ENGINES

FY	Potential Rebuildables From Cannibalization: Distribution According To Location				Number of Rebuildables Needed (From Available)			
	Total 100%	U.S. 85%	EUR 13%	PAC 2%	U.S.	EUR	PAC	TOT
77	592	503	77	12	88	0	0	88
78	78	66	10	2	66	0	0	66
79	79	67	10	2	67	0	0	67
80	571	485	74	11	304	0	0	304
81	-	0	0	0	0	0	0	0

Since 79 rebuildables will not be available in the U.S. during FY 78, the balance necessary should be obtained from supplies in the U.S. during previous years. Since there is a potential of 503 rebuildables in the U.S. during FY77, the balance should be drawn from this supply. The total requirement for U.S. is changed from the original 64 to 76. The total is also changed from 64 to 76 (but these changes are not shown on Table 7).

Similarly, in FY78 only 67 rebuildables will be available in the U.S. through cannibalization. Since a total of 79 is needed, attempt should be made to obtain the remaining 12 from the supplies in the U.S. during previous years before going to the supplies in Europe and Pacific during FY 79. A search for the supplies in U.S. during previous years shows that U.S. will have sufficient supply in FY77, to cover this difference. The requirement from U.S. for FY77 is again changed from 76 to 88, with a similar change in total requirement for FY77 (these final figures are shown on Table 7).

TABLE 8. SOURCE BREAK DOWN IN TERMS OF YEAR AND LOCATION FOR MULTIFUEL ENGINES

	Potential Rebuildables From Cannibalization: Distribution According to Location				Number of Rebuildables Needed (From Availables)			
	Total	U.S.	EUR	PAC	U.S.	EUR	PAC	TOT
FY	100%	67%	24%	9%				
77	105	70	25	9	70	25	9	105
78	103	69	25	9	69	25	9	103
79	101	68	24	9	68	24	9	101
80	99	66	24	9	66	24	9	99
81	97	65	23	9	65	23	9	97

E. Conversion:

Tables 7 and 8 show a breakdown of rebuildable engines needed in terms of year and location. However, in order to determine how many vehicles are to be cannibalized, it is necessary to take into account the losses in field and at depot level.

The loss rates for gas and multifuel engines are 0.325 and 0.37 respectively. Thus, for example, if 100 gas rebuildables are needed, it will be necessary to cannibalize, as a rule,

$$100 \div (1 - 0.325) = 148 \text{ vehicles.}$$

Tables 9 and 10 show actual cannibalization requirements in terms of time and location.

TABLE 9. CANNIBALIZATION SCHEDULE FOR EXCESS GAS TRUCKS

FY	Distribution of Cannibalization Requirements		
	U.S.	Europe	Pacific
77	130	0	0
78	99	0	0
79	98	0	0
80	450	0	0
81	0	0	0

TABLE 10. CANNIBALIZATION SCHEDULE FOR EXCESS MULTIFUEL TRUCKS

FY	Distribution of Cannibalization Requirements		
	U.S.	Europe	Pacific
77	112	40	15
78	110	39	15
79	107	38	15
80	105	38	15
81	103	37	15

F. <u>Cannibalization Costs</u>:

The costs for cannibalization involve three factors.

(1) Removal of engines from washed out vehicles
(2) Preparation of engines for shipment.
(3) Transportation of engines to depot in the U.S.

Cost breakdowns for gas and multifuel trucks are shown in Tables 11 and 12. (Courtesy of Cost Analysis Div, Comptroller).

TABLE 11 COST BREAKDOWN FOR CANNIBALIZATION OF GAS ENGINES

	YEAR (FY)	LOCATION U.S.	EUROPE	PACIFIC	TOTALS
REMOVAL OF ENGINES FROM WASHED OUT VEHICLES:	1977	7222	0	0	7222
	1978	5825	0	0	5825
	1979	6048	0	0	6048
	1980	28910	0	0	28910
	1981	0	0	0	0
					48005
PREPARATION OF ENGINES FOR SHIPMENT	1977	2942	0	0	2942
	1978	2373	0	0	2373
	1979	2464	0	0	2464
	1980	11779	0	0	11779
	1981	0	0	0	0
					19558
TRANSPORTATION OF ENGINES TO DEPOT IN U.S.	1977	20200	0	0	20200
	1978	16290	0	0	16290
	1979	16920	0	0	16920
	1980	80860	0	0	80860
	1981	0	0	0	0
					134270

Total cost for cannibalization of 777 gasoline engines = $201,833.
Average unit cost = $259.76.

TABLE 12: COST BREAKDOWN FOR CANNIBALIZATION OF MULTIFUEL ENGINES

	YEAR (FY)	LOCATION U.S.	EUROPE	PACIFIC	TOTALS
REMOVAL OF ENGINES FROM WASHED OUT VEHICLES:	1977	5761	2337	964	9062
	1978	5992	2413	1021	9426
	1979	6115	2466	1071	9652
	1980	6247	2568	1115	9930
	1981	6361	2595	1158	10114
					48184
PREPARATION OF ENGINES FOR SHIPMENT	1977	2535	1028	424	3987
	1978	2637	1062	449	4148
	1979	2690	1085	471	4246
	1980	2749	1130	491	4370
	1981	2799	1142	509	4450
					21201
TRANSPORTATION OF ENGINES TO DEPOT IN U.S.	1977	22230	11700	4980	38910
	1978	23120	12,080	5270	40470
	1979	23590	12350	5530	41470
	1980	24100	12850	5760	42710
	1981	24540	12990	5977	43507
					207067

Total cost for cannibalization of 800 multifuel trucks = $276,452.
Average unit cost = $345.57.

CONCLUSIONS

1. The shortage of 5 Ton Truck gasoline engines (R6602) can be successfully combated through cannibalization. However, cannibalization can solve only one fourth of the shortage as far as 5 Ton Truck multifuel engines (LDS 465/1A) are concerned, as shown on Table 5 of the report.

2. The costs associated with the computed cannibalization schedules are shown on Tables 11 and 12. The average unit costs for cannibalization of gas and multifuel engines are $259.76 and $345.57 respectively. The average unit cost is a function of the cannibalization schedule. Any change in the cannibalization schedules shown in Tables 9 and 10 will alter the unit costs due to escalation factors and location differentials.

RECOMMENDATIONS

1. In order to determine the cost-effectiveness of cannibalization, it is recommended that costs determined herein be compared to other possible alternatives.

2. The computer program inclosed with this study (Appendix) can be used to compute new cannibalization schedules and associated costs (as in Tables 9, 10, 11 and 12), if desired. Currently, the program output (sample inclosed) contains only the cannibalization requirements and matrices for the three cost factors shown on Tables 11 and 12. However, it is possible to modify the output routines to list more information.

APPENDIX

Documentation for the inclosed computer
program for calculating the cannibalization
requirements for 5 Ton Trucks can be obtained
on request from DRSTA-SA, USATARCOM, Warren,
MI 48090

The source and object files as well as the
absolute overlay for the loaded programs
are stored on permanent files on the CDC 6600
Computer System at Picatinny Arsenal, Dover, N.J.

```
      PROGRAM CONTROL(GAS,MULTI,INPUT,OUTPUT,TAPE1=GAS,
     P                 TAPE2=MULTI,TAPE5=INPUT,TAPE6=OUTPUT)
      REAL MO
      INTEGER RBLDNS
      DIMENSION MO(5),BO(5),SERV(5),UNSRV(5),
     D          PIPE(5),OTH(5),VEHNOR(5),DISTR(3),YRLY(5),
     D          DEF(5),CDEF(5),DEM(5),SUP(5),REQ(5),REBLDA(5),
     D          REBLDN(5,3),YEXESS(5),RBLDA(5,3),RBLDN(5,3),
     D          RBLDNS(5,3),BASECST(3),TRANSP(3)
      COMMON  /DEFICT/ROTL,MO,SERV,UNSRV,BO,PIPE,OTH,
     C                 DEF,CDEF,DEM,SUP,ROTG,YRLY
     C        /REBILDS/CURSTR,ENGL,VEHWOR,
     C                 YEXESS,REBLDA,ENGG
     C        /REQMNTS/
     C                 REBLDN
     C        /AVAILTL/DISTR,
     C                 RBLDA
     C        /RBLDNTL/
     C                 RBLDN
     C        /CSCHED/
     C                 RBLDNS
     C            /COST/BASECST,TRANSP
      DATA REPT1,REPT2/1HN,2HNO/
C
  111 CONTINUE
      CALL ZEROS
      CALL READER
      CALL DEFICT
      CALL REBILDS
      CALL REQMNTS(REBLDA,REBLDN,CDEF)
      CALL AVAILTL(REBLDA,REBLDN)
C        AVAILTL CALLS RBLDNTL
      CALL CSCHED(RBLDN,ENGG,RBLDNS)
      CALL COST(RBLDNS)
C        COST CALLS MATRCES
      WRITE(6,1)
    1 FORMAT(" ANOTHER RUN? ('N' OR 'NO' FOR NO) ")
      READ(5,2)REPT
2     FORMAT(A10)
      IF(REPT.NE.REPT1.AND.REPT.NE.REPT2)GOTO 111
      STOP
      END
C*****************EOP
```

```
C*****************EOF
      SUBROUTINE ZEROS
      DIMENSION REBLDN(5,3)
      COMMON/REQMNTS/REBLDN
      DO 111 I=1,15
      REBLDN(I)=0.
111   CONTINUE
      RETURN
      END
```

..

```
C****************
      SUBROUTINE READER
      INTEGER TAPE
      REAL MO
      LOGICAL RANDOM,TAPE5
      COMMON  /DEFICT/ROTL,MO(5),SERV(5),UNSRV(5),BO(5),
     C          PIPE(5),OTH(5),DEF(5),CDEF(5),DEM(5),SUP(5),
     C          POTG,YRLY(5)     /REBILDS/CURSTR,ENGL,VEHWOR(5),
     C          YEXESS(5),REBLDA(5),ENGG      /REQMNTS/REBLDN(5,3)
     C              /AVAILTL/DISTR(3),RBLDA(5,3)     /RBLDNTL/
     C          RBLDN(5,3)     /CSCHED/RBLDNS(5,3)
     C        /COST/BASECST(3),TRANSP(3)
      NAMELIST/NAMEALL/BO,PIPE,MO,OTH,SERV,UNSRV,ROTL,
     N                 VEHWOR,DISTR,CURSTR,ENGL,BASECST,TRANSP
      DATA REPT1,REPT2/1HN,2HNO/
C
111   WRITE(6,1)
1     FORMAT(" RANDOM READ?('N' OR 'NO' FOR NO)= ")
      READ(5,2)REPT
2     FORMAT(A10)
      RANDOM=.FALSE.
      IF(REPT1.NE.REPT.AND.REPT2.NE.REPT)RANDOM=.TRUE.
      WRITE(6,3)
3     FORMAT(" TAPE(INTEGER)=? ")
      READ(5,*)TAPE
      TAPE5=TAPE.EQ.5
      IF((RANDOM.AND.TAPE5).OR.(.NOT.RANDOM.AND..NOT.TAPE5))
     L  GOTO 122
      WRITE(6,4)RANDOM,TAPE
4     FORMAT(" RANDOM=",L1," AND TAPE=",I2," NOT PERMITTED"/
     4          " RE-ENTER...")
      GOTO 111
122      IF(RANDOM)GOTO 133
         REWIND TAPE
         READ(TAPE,NAMEALL)
         GOTO 144
133      WRITE(6,5)
5        FORMAT(" ENTER VALUES INTO NAMELIST $NAMEALL"/)
         READ(TAPE,NAMEALL)
144   RETURN
      END
C****************
```

```
C******************
      SUBROUTINE DEFICT
      REAL MO,MOPERYR
      LOGICAL CDEFNEG
      DIMENSION MO(5),SERV(5),UNSRV(5),BO(5),PIPE(5),OTH(5),
     D           DEF(5),CDEF(5),DEM(5),SUP(5),YRLY(5),MOPERYR(5)
      COMMON/DEFICT/ROTL,MO,SERV,UNSRV,BO,PIPE,OTH,
     C            DEF,CDEF,DEM,SUP,ROTG,YRLY
      DATA MOPERYR/4.0,4*12.0/
C
      DEFI=0.0
      ROTG=1.0-ROTL
         DO 111 I=1,5
         YRLY(I)=MO(I)*MOPERYR(I)
         RECOVER=YRLY(I)*ROTG
         SUP(I)=SERV(I)+UNSRV(I)+RECOVER
         DEM(I)=BO(I)+PIPE(I)+YRLY(I)+OTH(I)
         DEF(I)=DEM(I)-SUP(I)
         CDEF(I)=DEF(I)+DEFI
         CDEFNEG=CDEF(I).LT.0.0
            DEFI=0.0
            IF(CDEFNEG)DEFI=CDEF(I)
            IF(CDEFNEG)CDEF(I)=0.0
  111    CONTINUE
      RETURN
      END
C******************
```

```
C*****************
      SUBROUTINE REBILDS
      DIMENSION VEHWOR(5),REBLDA(5),YEXESS(5)
      COMMON/REBILDS/CURSTR,ENGL,VEHWOR,
     C                  YEXESS,REBLDA,ENGG
C
      ENGG=1.0-ENGL
      DO 111 I=1,5
      YEXESS(I)=CURSTR*VEHWOR(I)
      REBLDA(I)=YEXESS(I)*ENGG
      CURSTR=CURSTR-YEXESS(I)
  111 CONTINUE
      RETURN
      END
C*****************
```

```
C*****************
      SUBROUTINE REQMNTS(REBLDA,REBLDN,CDEF)
      DIMENSION REQ(5),CDEF(5),REBLDA(5),REBLDN(5,3)
C
      I=1
  100 REQ(I)=CDEF(I)
      II=I
111   IF(REQ(II).GT.REBLDA(II))GOTO 133
      REBLDN(II,1)=REQ(II)
122   IF(I.EQ.5)GOTO 155
      I=I+1
      GOTO 100
133   REBLDN(II,1)=REBLDA(II)
      SHORT=REQ(II)-REBLDA(II)
      REQ(II)=REBLDA(II)
      IF(II.EQ.1)GOTO 144
      II=II-1
      REQ(II)=REQ(II)+SHORT
      GOTO 111
144   WRITE(6,1)I,SHORT
1     FORMAT(" WARNING: NEEDS FOR",I2,"TH YEAR CANNOT BE MET"/
     1        F6.0," REBUILDABLES SHOULD BE MADE AVAILABLE.")
      GOTO 122
155   RETURN
      END
C*****************
```

```
C*****************
      SUBROUTINE AVAILTL(REBLDA,REBLDN)
      DIMENSION DISTR(3),REBLDA(5),REBLDN(5,3),RBLDA(5,3)
      COMMON/AVAILTL/DISTR,
     C                 RBLDA
C
      DO 122 J=1,3
      DISTRIB=DISTR(J)
         DO 111 I=1,5
         RBLDA(I,J)=REBLDA(I)*DISTRIB
111      CONTINUE
      CALL RBLDNTL(RBLDA,REBLDN,J)
122   CONTINUE
      RETURN
      END
C*****************
```

```
C*****************
      SUBROUTINE RBLDNTL(RBLDA,REBLDN,J)
      DIMENSION RBLDA(5,3),REBLDN(5,3),RBLDN(5,3)
      COMMON/RBLDNTL/RBLDN
C
      I=1
100   II=I
111   IF(REBLDN(II,J).GT.RBLDA(II,J))GOTO 133
      RBLDN(II,J)=REBLDN(II,J)
122      IF(I.EQ.5)GOTO 155
         I=I+1
         GOTO 100
133   RBLDN(II,J)=RBLDA(II,J)
      SHORT=REBLDN(II,J)-RBLDA(II,J)
      REBLDN(II,J)=RBLDA(II,J)
         IF(II.EQ.1)GOTO 144
         II=II-1
         REBLDN(II,J)=REBLDN(II,J)+SHORT
         GOTO 111
144      REBLDN(I,J+1)=SHORT
         GOTO 122
155   RETURN
      END
C*****************
```

```
C******************
      SUBROUTINE CSCHED(RBLDN,ENGG,RBLDNS)
      INTEGER RBLDNS
      DIMENSION RBLDN(5,3),RBLDNS(5,3)
      IYR=1976
      WRITE(6,1)
1     FORMAT(///" FY",10X,"DISTRIB OF CANNIB REQMNTS"/
     C              13X,"U.S.     EUROPE     PACIFIC"/)
      DO 122 I=1,5
      IYR=IYR+1
          DO 111 J=1,3
          RBLDNS(I,J)=AINT(5.0001E-1+RBLDN(I,J)/ENGG)
111       CONTINUE
      WRITE(6,2)IYR,(RBLDNS(I,J),J=1,3)
2     FORMAT(I5,8X,3(I6,2X))
122   CONTINUE
      RETURN
      END
C******************
```

```
C*****************
      SUBROUTINE COST(RBLDNS)
      INTEGER RBLDNS
      REAL LOC,LOCDIFF
      DIMENSION BASECST(3),TRANSP(3),ESCFACT(5),LOCDIFF(3,3),
     D         RBLDNS(5,3),COSTS(5,3,3)
      COMMON/COST/BASECST,TRANSP
      DATA LOCDIFF/2*(1.0,1.136,1.250),3*0.0/,
     D     ESCFACT/1.0750,1.1385,1.1943,1.2433,1.2906/
C
      DO 100 J=1,3
      LOCDIFF(J,3)=TRANSP(J)
100   CONTINUE
      TOTAL=0.0
      DO 133 K=1,3
      UNITCOS=BASECST(K)
         DO 122 J=1,3
         LOC=LOCDIFF(J,K)
            DO 111 I=1,5
            COSTS(I,J,K)=ESCFACT(I)*RBLDNS(I,J)*LOC*UNITCOS
            TOTAL=TOTAL+COSTS(I,J,K)
111         CONTINUE
122      CONTINUE
133   CONTINUE
      CALL MATRCES(COSTS,TOTAL)
      RETURN
      END
C*****************
```

```
C******************
      SUBROUTINE MATRCES(COSTS,TOTAL)
      REAL LOC,LOCDIFF
      DIMENSION COSTS(5,3,3),WORDS(5,3),COSTLOC(3),IYR(5)
      DATA IYR/1977,1978,1979,1980,1981/,
     D     WORDS/10HENGINE REM,10HOVAL COST ,7HMATRIX:,2*1H ,
     D           10HPREPARATIO,10HN-FOR-TRAN,10HSPORTATION,
     D                                        10H COST MATR,3HIX:,
     D           10HENGINE TRA,10HNSPORTATIO,10HN COST MAT,
     D                                          4HRIX:,1H /
      DO 111 K=1,3
      WRITE(6,1)(WORDS(J,K),J=1,5)
1     FORMAT(///1X,5A10//)
      WRITE(6,2)
2     FORMAT(" FY",20X,"LOCATION"/17X,"U.S.     EUROPE    PACIFIC"/)
      WRITE(6,3)((IYR(I),(COSTS(I,J,K),J=1,3)),I=1,5)
3     FORMAT(5(I5,6X,3(2X,F8.0)/))
111   CONTINUE
C
      WRITE(6,4)
4     FORMAT(///" MATRIX OF COSTS WITH RESPECT TO TIME & ",
     4            " LOCATION:"//)
      WRITE(6,2)
      DO 144 I=1,5
         DO 133 J=1,3
         COSTLOC(J)=0.0
            DO 122 K=1,3
            COSTLOC(J)=COSTLOC(J)+COSTS(I,J,K)
122         CONTINUE
133      CONTINUE
         WRITE(6,5)IYR(I),COSTLOC
5        FORMAT(I5,6X,3(2X,F8.0))
144   CONTINUE
      WRITE(6,6)TOTAL
6     FORMAT(///" TOTAL COST FOR THE ENTIRE OPERATION IS $",
     6 '       F8.0////)
      RETURN
      END
```

GAS ENGINES

```
C*****************
 $NAMEALL BO=450.,4*0.,PIPE=156.,4*0.,MO=5*39.,
  OTH=5*0.,SERV=222.,4*0.,UNSRV=518.,4*0.,ROTL=0.325,
  VEHWOP=0.13,2*0.02,0.15,0.0,DISTR=0.85,0.13,0.02,
  CURSTR=6752.,ENGL=0.325,BASECST=51.68,21.05,144.53,
  TRANSP=1.0,1.474,1.673$
C*****************
```

DATA FOR CALCULATION OF GAS ENGINES (FILE "GAS")

FY	DISTRIB OF CANNIB REQMNTS U.S.	EUROPE	PACIFIC
1977	130	0	0
1978	100	0	0
1979	98	0	0
1980	451	0	0
1981	0	0	0

ENGINE REMOVAL COST MATRIX:

FY	U.S.	LOCATION EUROPE	PACIFIC
1977	7222.	0.	0.
1978	5884.	0.	0.
1979	6049.	0.	0.
1980	28978.	0.	0.
1981	0.	0.	0.

PREPARATION-FOR-TRANSPORTATION COST MATRIX:

FY	U.S.	LOCATION EUROPE	PACIFIC
1977	2942.	0.	0.
1978	2397.	0.	0.
1979	2464.	0.	0.
1980	11803.	0.	0.
1981	0.	0.	0.

ENGINE TRANSPORTATION COST MATRIX:

FY	LOCATION U.S.	EUROPE	PACIFIC
1977	20198.	0.	0.
1978	16455.	0.	0.
1979	16916.	0.	0.
1980	81042.	0.	0.
1981	0.	0.	0.

MATRIX OF COSTS WITH RESPECT TO TIME & LOCATION:

FY	LOCATION U.S.	EUROPE	PACIFIC
1977	30362.	0.	0.
1978	24735.	0.	0.
1979	25428.	0.	0.
1980	121824.	0.	0.
1981	0.	0.	0.

TOTAL COST FOR THE ENTIRE OPERATION IS $ 202349.

MULTIFUEL ENGINES

```
C******************
 $NAMEALL BO=330,4*0.,PIPF=468.,4*0.,MO=5*117.,
  OTH=5*0.,SERV=153.,4*0.,UNSRV=856.,4*0.,
  ROTL=0.37,VEHWOR=5*0.02,DISTR=0.67,0.24,0.09,CURSTR=8323,
  ENGL=0.37,BASECST=47.84,21.05,184.63,TRANSP=1.0,1.474,1.673$
C******************
```

DATA FOR CALCULATION OF MULTIFUEL ENGINES (FILE "MULTI")

```
WARNING: NEEDS FOR 2TH YEAR CANNOT BE MET
 274. REBUILDABLES SHOULD BE MADE AVAILABLE.
WARNING: NEEDS FOR 3TH YEAR CANNOT BE MET
 419. REBUILDABLES SHOULD BE MADE AVAILABLE.
WARNING: NEEDS FOR 4TH YEAR CANNOT BE MET
 421. REBUILDABLES SHOULD BE MADE AVAILABLE.
WARNING: NEEDS FOR 5TH YEAR CANNOT BE MET
 423. REBUILDABLES SHOULD BE MADE AVAILABLE.
```

FY	DISTRIB OF CANNIB REQMNTS		
	U.S.	EUROPE	PACIFIC
1977	112	40	15
1978	109	39	15
1979	107	38	14
1980	105	38	14
1981	103	37	14

ENGINE REMOVAL COST MATRIX:

FY	LOCATION		
	U.S.	EUROPE	PACIFIC
1977	5760.	2337.	964.
1978	5937.	2413.	1021.
1979	6113.	2466.	1000.
1980	6245.	2568.	1041.
1981	6359.	2595.	1080.

PREPARATION-FOR-TRANSPORTATION COST MATRIX:

FY	LOCATION		
	U.S.	EUROPE	PACIFIC
1977	2534.	1028.	424.
1978	2612.	1062.	449.
1979	2690.	1085.	440.

ENGINE TRANSPORTATION COST MATRIX:

FY	LOCATION U.S.	EUROPE	PACIFIC
1977	22229.	11702.	4981.
1978	22912.	12084.	5275.
1979	23594.	12351.	5165.
1980	24103.	12858.	5377.
1981	24543.	12996.	5581.

MATRIX OF COSTS WITH RESPECT TO TIME & LOCATION:

FY	LOCATION U.S.	EUROPE	PACIFIC
1977	30524.	15067.	6369.
1978	31461.	15558.	6746.
1979	32397.	15903.	6604.
1980	33096.	16555.	6875.
1981	33701.	16733.	7137.

TOTAL COST FOR THE ENTIRE OPERATION IS $ 274727.